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(Bulletins 296 to 304 constitute the Report for 1921. In binding, pages i-xii at the end of this bulletin should be detached and placed before Bulletin 296 which begins with page 1.)

Maine Agricultural Experiment Station

ORONO

BULLETIN 304

DECEMBER, 1921

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MAINE
AGRICULTURAL EXPERIMENT STATION
ORONO, MAINE

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*Resigned November 1.

BULLETIN 304

ABSTRACTS OF PAPERS PUBLISHED BY THE STATION IN 1921 BUT NOT INCLUDED IN THE BULLETINS.

A complete list of all the publications issued by and from the Station in 1921 is given on pages x to xii of the introduction to this Report. The following pages contain abstracts of the papers issued during the year that are not included in the Bulletins or Official Inspections for the year.

STERILITY IN WHEAT HYBRIDS.

I. STERILITY RELATIONSHIPS AND ENDOSPERM DEVELOPMENT.¹

This paper furnishes an analysis of the sterility relationship in wheat as determined by a study of (1) the endosperm development in fertile and sterile crosses; (2) sterility in species crosses as determined by grains set and pollen counts; (3) hybrid vigor of F_1 plants in relation to sterility; and (4) size and variability of pollen grains in parents and F_1 plants.

Crosses of wheat species which produce sterile or partially sterile F_1 hybrids also produce small wrinkled F_1 grains. Fertile crosses produce large plump grains often larger than the grains of the female parent. Both fertile and sterile or partially sterile F_1 plants are usually more vigorous than the parents. Sterile combinations which produce small wrinkled F_1 endosperms produce large vigorous F_1 plants. The chromosome constitution of the F_1 endosperm and the F_1 plant is identical with the exception that the F_1 endosperm has an extra set of maternal chromosomes. The individual chromosomes are identical and carry the same factors.

It is evident that groups of chromosomes which are incompatible in gamete formation can function normally in the vegetative development of the plant so long as the paternal and maternal sets of chromosomes are intact. In partially sterile crosses the addition of an extra set of maternal chromosomes in case

¹This is an abstract from a paper by Karl Sax having the same title and published in Genetics, Vol. 6, pp. 399-416, July, 1921.

of the endosperm is correlated with abnormal development. In fertile combinations the extra set of maternal chromosomes in the endosperm causes no abnormal growth, unless endosperm formation itself is considered abnormal. In fertile wheat crosses we get hybrid vigor in both F_1 endosperm and F_1 plant as in corn. In partially sterile crosses, however, we get a reduced development of the F_1 endosperm and yet the F_1 plant is unusually vigorous. Apparently the hybrid endosperm is not always adapted to the needs of the hybrid embryo. In sterile or partially sterile wheat hybrids where the chromosomes are incompatible in gamete formation the behavior of the 3x chromosomes in the F_1 endosperm development is not comparable with the behavior of the 2x chromosomes in the corresponding F_1 plant development.

The degree of sterility of a wheat hybrid may be determined by the amount of grain set on the F_1 plant and by the amount of aborted pollen. In addition a sterile or fertile cross can be recognized at once by the size and appearance of the F_1 grain resulting from the immediate cross. Sterile or partially sterile crosses produce small wrinkled F_1 grains, while fertile crosses produce grains as large or larger than those of the maternal parent. Comparisons are made only with the grains of the female parent because the F_1 grains are also borne on the female parent and size and shape of grain is normally dependent on the mother plant only.

The general sterility relationships in wheat can be made as follows.

a. Einkorn group: *T. monococcum*. Varieties inter-fertile; sterile or only slightly fertile with groups b and c.

b. Emmer group: *T. dicoccum*, *T. durum*, *T. turgidum* and *T. polonicum*. Species and varieties inter-fertile; sterile or slightly fertile with group a; partially sterile with group c.

c. *Vulgare* group: *T. spelta*, *T. vulgare* and *T. compactum*. Species and varieties inter-fertile; sterile or slightly fertile with group a; partially sterile with group b.

The sterility relationships of the above species groups are based on gametic sterility and do not apply to sterility as reported in the cross of Bluestem x Amby.

The available data indicate that the size of pollen grains vary significantly in different species of *Triticum*. The average

volume of the pollen grains expressed in thousands of cubic microns was found to be 72 for Einkern, 94 for Kubanka and Alaska (Emmer group) and 114 for Marquis and Hybrid 143 (*vulgare* group). It is rather remarkable that pollengrain size is so closely correlated with the sterility relationships of the three groups of wheat species. The size of pollen grains has little or no effect on the percentage of grain set in crossing. Crosses between members of the Emmer and *vulgare* groups are about as easy to effect as crosses within each group.

The pollen grains of the F_1 plants are more variable than those of the parents, due presumably to recombinations of maternal and paternal chromosomes in the haploid generation.

A varietal cross within the *vulgare* group produced F_1 plants, which failed to develop beyond the rosette stage, presumably due to lethal or inhibiting factors.

STUDIES ON CONFORMATION IN RELATION TO MILK PRODUCING CAPACITY IN CATTLE.

II. THE PERSONAL EQUATION OF THE CATTLE JUDGE.²

This paper presents an analysis of the judging ability of a group of 19 men, judging ability being based on whether or not the judge can place dairy cows by their conformation and at the same time place them in order of their milk yield. The study of the average score given each group of cows by the different judges showed that a wide divergence of opinion exists as to what score should be given to animals of a given milk yield. This, of course, does not say that the judges who score all of their cattle high for a given average of milk production are better judges of milk yield from conformation than those who score their cattle lower. In fact the reverse may be the case. The only difference is that the mental scale of the value of conformation for milk yield differs in men, causing the resulting score on cows of the same milk yield to be lower or higher in accord with the relative level of their mental scale.

²This is an abstract from a paper by John W. Gowen having the same title and published in Journal of Dairy Science, Vol. IV, No. 5, pp. 359-374, September, 1921.

While these mental scales are different they do show that there is some common ground between them for a comparison of the average milk yields and scores, the low milk yields tending to go with the low scores and the high milk yields with the high scores. The mental scales for conformation and its standards as held by these 19 judges are independent of their judging ability. Thus two equally good judges might place the same cow many points apart on score but would in the show ring place her in the same relative position, say second place, among her competitors. Cows with larger average milk yields are shown to be easier to judge than are cows whose milk yields are less.

Comparison of the individual judges shows that only about one man in two can judge a cow and select her for her milk yield. While this indicates the points of conformation as worth something as a means of predicting milk yield, still it does not make them worth a great deal. If comparison is made between this figure and that for the relation of a milk yield of short duration (seven days) with the milk yield of the year period it is found that the milk yield is nearly two times as valuable as an indicator of milk production over the long period as is the conformation of the cow even though this conformation be judged by men of long experience.

IDENTICAL TWINS IN CATTLE.³

This paper presents a study of the sex ratio and color markings of twins births to determine if identical twins appear in cattle. The sex ratio of twin births is approximately a 1:2:1 ratio for data which are known to be based on random sampling. The color marking of like twins are but little more alike than the color markings of unlike twins. Such being the case, it cannot be argued that twins of identical markings, tongue color or switch color exist in cattle. In fact if identical twins in cattle occur at all they occur only infrequently say not over 3 to 5 per cent.

³This is an abstract from a paper by John W. Gowen having the same title and published in the Biological Bulletin, Vol. XLII, No. 1, pp. 1-7, January, 1922.

COMPLETE LINKAGE IN DROSOPHILA MELANO-GASTER.⁴

The cultures of the authors contained a mating which, in 1917, gave a stock of flies that have no crossingover for the sex chromosome, the second chromosome and the third chromosome of *Drosophila melanogaster*. The disturbance is due to a recessive factor located in the third chromosome. This recessive factor affects only the crossingover mechanism, so far as it is possible to determine.

STUDIES IN MILK SECRETION.

X. THE RELATION BETWEEN THE MILK YIELD OF ONE LACTATION AND THE MILK YIELD OF A SUBSEQUENT LACTATION IN GUERNSEY ADVANCED REGISTRY CATTLE.⁵

This paper presents an analysis of the Guernsey Advanced registry records to determine what relation exists between the milk yield of one lactation and that of another.

Environment may materially effect the milk yield of a cow. Thus Guernsey cows on retest produced over 1000 pounds milk more than their sisters on first test at the same age. The variation of Guernsey milk yield agrees with that of the other breeds. The relation of the milk yield of one lactation to that of another is high ranging from 0.462 to .811 in the correlation scale. Compared with a pure bred herd of Jerseys the average coefficient of correlation is nearly .15 higher for the Guernsey advanced registry cattle than it is for the Jerseys. Compared with the records for egg production, the Guernsey milk records indicate with much greater accuracy what the subsequent retest milk record will be than do the egg records for one month indicate what the subsequent eleven months egg record will be for white leghorn hens. Equations are presented to determine from one lactation's advanced registry record what will be the probable record at a subsequent lactation.

⁴This is an abstract from a paper by Marie S. Gowen and John W. Gowen having the same title and published in the American Naturalist.

⁵This is an abstract from a paper by John W. Gowen having the same title and published in the Journal of Dairy Science.

STUDIES IN MILK SECRETION.

XI. THE RELATION BETWEEN THE BUTTER-FAT PERCENTAGE OF ONE LACTATION AND THE BUTTER-FAT PERCENTAGE OF A SUBSEQUENT LACTATION IN GUERNSEY ADVANCED REGISTRY CATTLE.⁶

This paper presents data to show the reliability of an advanced registry record of Guernsey cattle in predicting what the cow will do in a subsequent advanced registry retest for other lactations. The principal facts resulting from this study may be briefly stated as follows. Unlike milk yield the butter-fat percentage of these Guernsey advanced registry cows shows no increase on retest. It remains approximately the same in the retest as in the first test. The variation of the butter-fat percentage is closely similar to that of other breeds of cattle. The relation of the butter-fat percentage of one lactation to that of another is high ranging from .637 to .893 in terms of the correlation scale. The average correlation coefficient is .792. This average is 1.1 times as high as that for milk yield of these same cows or a butter-fat percentage record may be more accurately predicted from a previous test than can a record for milk yield be predicted from a previous test. Comparison of these results with records of a pure bred Jersey herd for the relation of one lactation to another, indicates that the advanced registry records predict a subsequent advanced registry performance more accurately than would be expected to be the case for all Guernsey cows. A comparison of the value of a month's egg record in predicting the other eleven months' record with Guernsey butter-fat percentage records shows that a Guernsey butter-fat percentage record predicts more accurately the subsequent butter-fat percentage record than does an egg record predict the subsequent performance of the hen. Comparison of scoring as a method of selecting cattle for milk yield or butter-fat percentage with an advanced registry record for selecting milch cows shows the advanced registry record to be several times more valuable than the score card. Equations are presented to determine from one lactation's advanced registry butter-fat percentage record

⁶This is an abstract from a paper by John W. Gowen having the same title and published in the Journal of Dairy Science.

what the probable butter-fat percentage record at a subsequent lactation will be.

WHEAT INVESTIGATIONS.

II. CORRELATIONS BETWEEN VARIOUS CHARACTERS OF WHEAT AND FLOUR AS DETERMINED FROM PUBLISHED DATA FROM CHEMICAL, MILKING AND BAKING TEST OF A NUMBER OF AMERICAN WHEATS.⁷

The data presented in this paper pertain to the relationships which exist between crude protein, dry gluten, gliadin, water absorption, flour yield and loaf volume for the wheats found in different parts of the country. The general conclusions briefly stated are as follows.

Crude protein content in the wheat is very closely and consistently correlated with protein in flour, dry gluten and gliadin. There appears to be practically no relation between crude protein content in the wheat and flour yield. There is, with some notable exceptions, a high positive correlation between the crude protein in the wheat and strength of flour as determined by the loaf volume. There is generally even a higher, positive correlation between protein in the flour and loaf volume. The gluten content of the flour is very closely correlated with loaf volume. The intensity of association between these two variables appears to be greater than that for protein in flour and loaf volume. There is generally a high, positive correlation between wet gluten content and loaf volume. There is, with some exceptions, a positive, fairly high correlation between water absorption of the dough and loaf volume. In normal, sound wheat there is apparently no significant correlation between flour yield and loaf volume. Excepting the data for a few wheat groups, there is a positive, and, for some wheat groups a very high correlation between gliadin content and loaf volume. Dry gluten content is generally highly correlated with gliadin content. From the scant data for dry gluten content and water absorption it would seem that there is no significant correlation between these two variables, which is contrary to expectation. Loaf volume is associated more closely

⁷This is an abstract from a paper by Jacob Zinn having the same title and published in the Journal of Agricultural Research.

with gluten quality as indicated by the correlation ratio than with any other character considered. There appears to be a constant and fairly high correlation between the content and quality of gluten.

STUDIES IN MILK SECRETION.

XIII. RELATION BETWEEN THE MILK YIELDS AND BUTTER-FAT PERCENTAGES OF THE 7 DAY AND 365 DAY TESTS OF HOLSTEIN-FRIESIAN ADVANCED REGISTRY CATTLE.⁸

This paper presents a study of the variability of the 7 day and 365 day records in Holstein-Friesian advanced registry testing. The following are the major conclusions derived from the results.

The coefficients of variation for the 7 day milk yields are less than the coefficients of variation for the 365 day milk yields. The coefficients of variation for the 7 day butter-fat percentages are greater than the coefficients of variation for the 365 day butter-fat percentages.

The correlation coefficients between the 365 day milk yields or butter-fat percentages and those of a subsequent lactation are all large. The correlation coefficients for the 7 day milk yields or butter-fat percentages and those of the 365 day period, when the 7 day test is a part of the 365 day test, are high but not as high as those for the 365 day test with the subsequent 365 day test. The correlation coefficient for the 7 day test and the 365 day test, when the 7 day test is not a part of the 365 day test, are slightly lower than either of the other two tests. All records have a significantly high value.

The comparison of the correlation coefficients and the correlation ratios shows that the regression lines are linear.

The 7 day and 365 day records as measures of subsequent production are compared with other records like egg production for the month as an indicator of the egg production for the year. These comparisons show that the 7 day and 365 day records are fully on a par with the other agencies used to predict other economic variables.

⁸This is an abstract from a paper by John W. Gowen having the same title and published in the Journal of Dairy Science.

When all records are grouped irrespective of the ages of the cows at test, the order of merit of the 7 day and 365 day records for milk yield is changed. This is due to the effect of age on milk yield causing a heterogeneity in the data.

No significant difference is found in the value of the 7 day test as a measure of the 365 day test at the present time as compared with it as a measure of this same variable in the past.

Prediction equation to determine the milk yield or butter-fat percentage of the 7 day record from the 365 day records, the 365 day record from the 7 day records or the 365 day record from the 365 day record are presented.

STUDIES IN ORCHARD MANAGEMENT.

IV. PRODUCTIVE AND UNPRODUCTIVE TYPES OF APPLE TREES.⁹

This paper presents a study of 881 Ben Davis trees to show that productive and unproductive trees are closely associated with definite types or habits of growth. The productive, or type 1, trees are large, open and spreading, with short laterals and many spurs. The unproductive, or type 3, trees are small and upright with slender branches and few spurs. Between these two extreme types are a number of intermediate types.

Such differences as these call for an explanation. In the light of a critical analysis of the literature the differences in productivity of trees of a clonal variety may be attributed to soil, root stocks, bud variation, or to unknown factors. In the Ben Davis orchard, soil was found to be an important factor in causing differences in type and yield of trees. The influence of favorable or unfavorable root stocks is also an important factor in tree growth and productivity. There is no critical evidence that differences in productivity within a clonal variety are due to bud variation.

⁹This is an abstract from a paper by Karl Sax and John W. Gowen having the same title and published in the Journal of Heredity, Vol. XII, No. 7, pp. 290-350.

CHROMOSOME RELATIONSHIPS IN WHEAT.¹⁰

The chromosome groups for the different species of wheat are determined by a study of the germ cells. Einkorn has 7 haploid chromosomes; the Emmer group, consisting of *T. dicoccum*, *T. durum*, *T. turgidum* and *T. polonicum* has 14 haploid chromosomes, and the Vulgare group, consisting of *T. vulgare* and *T. compactum*, has 21 haploid chromosomes.

A study of the sterility relationships of species crosses has already been completed and is of considerable interest in connection with the chromosome number. Einkorn with 7 chromosomes crossed with members of the Emmer group with 14 chromosomes or with members of the Vulgare group with 21 chromosomes, results in almost totally sterile F₁ plants. Members of the Emmer group crossed with members of the Vulgare group result in only partially sterile F₁ individuals. Species within each group are inter-fertile. There is some evidence that the larger chromosome numbers are due to reduplication rather than fragmentation. If we assume that the size of a given cell is dependent on the chromosome content, the relationship of the three groups of wheat species becomes clearer. We have found that the volume of the mature pollen grains, measured in thousands of cubic microns, is about 72 for Einkorn, 94 for the Emmer group, and 114 for the Vulgare group. The differences in chromosome numbers of the three groups of species are closely associated with corresponding differences in size of pollen grains.

SIMPLE DEVICE FOR WEIGHING SEEDS.¹¹

This paper gives a description of an apparatus for accurate and rapid weighing of seeds like those of wheat or beans.

¹⁰This is an abstract from a paper by Karl Sax, having the same title and published in Science N. S., Vol. LIX, No. 1400, pp. 413-415. October 28, 1921.

¹¹This is an abstract of a paper by Karl Sax having the same title and published in the Botanical Gazette, Vol. LXXI, No. 5, p. 399, May, 1921.

LEAFROLL, NET-NECROSIS, AND SPINDLING- SPROUT OF THE IRISH POTATO.¹²

This paper summarizes results of experiments, conducted mostly in Maine, upon certain potato diseases.

Diseased conditions known as leafroll, net-necrosis, and spindling-sprout each may have several causes. This paper is concerned only with such conditions in which the cause is a certain "virus." The exact nature of the virus is not known, but its presence can be recognized by the effects, which are distinguished from those with other causes.

Leafroll is common and decreases the yield. Net-necrosis and spindling-sprout are less common, but are more injurious when present.

Transmission of leafroll from season to season occurs in tubers produced by diseased hills. Plants may appear healthy throughout the season and yet, if infected late, may have diseased progeny.

The infectiousness of the disease was demonstrated by means of tuber grafts and stem grafts. This was done in part in the field with plant lice eliminated.

Plant lice were also a means for transferring the disease. As more conditions favored the dispersal of these insects from diseased plots to healthy plants, there followed greater spread of the disease, both in the open field and in the greenhouse. These insects also transmitted leafroll when transferred from one caged plant to another.

Tests were made that indicated that soil was not an effective means of transmission of leafroll.

The same virus may cause both leafroll and net-necrosis, and net-necrosis usually causes spindling-sprout. The leafroll virus causes net-necrosis more often as certain conditions occur in regard to variety, tuber weight, and time elapsed after infection or harvesting.

A more northern climate seems to decrease the spread of leafroll. It appears that in a given region the most important measures to be taken to prevent the spread of leafroll in a sus-

¹²This is an abstract of a paper by Donald Folsom and a cooperating member of the Bureau of Plant Industry, having the same title and published in *Journal of Agricultural Research*, Vol. XXI, No. 1, p. 47-80.

ceptible variety are those which will reduce or prevent dispersal of insects from diseased to healthy plants, and which will eliminate diseased tubers. These are isolation of the seed-plot, use of the larger tubers for seed, and removal of diseased hills.

EFFECTS UPON THE GROWTH OF POTATOES, CORN AND BEANS RESULTING FROM THE ADDITION OF BORAX TO THE FERTILIZER USED.¹³

This is a continuation of the studies upon the injurious effects of borax in fertilizers, which were begun at this Station and published in Bulletin 288. The work here reported was conducted in the greenhouses of the Vermont Station under the joint auspices of the New England, New York and New Jersey Stations.

The chief purpose of the experiments reported in this publication was to determine whether the injuries previously observed both in the field and in the greenhouse were due alone to the borax present in the fertilizers and, if so, what is the maximum amount of borax that can be applied per acre to land on which important food plants are grown, without causing this injury. Potatoes, corn and beans were selected as representatives of three different types of such plants. The plan followed provided that the soil in a pot containing borax, for example, should differ in only one respect in its fertilizing treatment from a pot of the same soil containing none of this substance. All of the fertilizer used consisted of a single basal mixture prepared from materials of known composition and borax-free. Equal amounts of this fertilizer were used alone, and with additions of definite amounts of borax in pots of the same size in which the different types of plants were grown. Some comparisons were also made with a commercial fertilizer with which field and greenhouse records had been obtained previously with potatoes. Attempts were made to determine the effect of distributing the fertilizer above and below the seed or seed-piece, both in drills and mixed with the soil. Ground limestone, hydrated lime, gypsum and manure were added to the pots in some instances in

¹³This is an abstract of a paper by J. R. Neller and W. J. Morse, having the same title and published in Soil Science, Vol. 12, pp. 79-105, August, 1921.

order to determine whether they would neutralize the toxic effects of borax, wholly or in part.

The soil used resembled a sandy clay loam and had a maximum water capacity of 37.5 per cent by the Hilgard method. It contained 4.22 per cent of volatile matter and had a lime requirement, or absorption coefficient of 320 pounds per acre. The pots used were solid glazed jars in order to prevent any accumulation of borax or fertilizing ingredients in the walls of the pots as might occur with porous pots as the result of constant evaporation of soil water from their outer surfaces. Provision was made to water the soil in the pots both from the top and the bottom. In the greater part of the experiments the soil was maintained at 50 per cent of its water-holding capacity.

The following is a summary of the effects observed on potatoes, corn and beans resulting from the additions of varying amounts of borax to the fertilizer used in the pots in which the plants were grown.

EFFECTS ON POTATOES

The application of 2 pounds of borax per acre caused no injury to potato plants, while a few of the plants where 5 pounds per acre were added exhibited a slight injury to the lower leaves.

The additions of 10 and 20 pounds of borax per acre caused a marked injury and retardation, especially when applied below the seed-pieces.

In general the toxic limit of borax for potatoes under the conditions of the experiment was somewhat above 5 pounds per acre.

When applied above the seed-pieces there was no noticeable effect on potato foliage when the plants were young, but later they developed excessive leaf injury where borax was present at the rates of 10 or 20 pounds per acre.

Borax-fertilizer mixtures applied below the seed-pieces proved to be the most toxic, particularly when in drills. The plants receiving the heavier applications were stunted from the first and often developed considerable leaf injury also.

The higher borax applications caused considerable injury to root systems and decrease in tuber yields, especially when applied below the seed-piece. Stem injury, both above and below surface of the soil, was most marked where the plants grew

normally at first, but were injured later by the borax which had been applied above the seed-piece.

Both finely ground limestone and hydrated lime appeared to neutralize some of the toxicity of borax when applied in drills below the seed-piece at the rate of 10 pounds per acre.

Plants grown in pots fertilized with a commercial fertilizer containing borax developed the same types of injury as occurred where borax-fertilizer mixtures were applied. Boron was found to be present in the affected leaves in both cases.

EFFECTS ON CORN

Corn plants appear to be particularly sensitive to borax when young but more resistant when older.

For this reason the toxic limit of borax for corn depends largely upon the method of application. The tests showed that borax-fertilizer applications below the seed are much more liable to be toxic than those above or those which are mixed with the surface soil.

It was apparent that the application of 1 and 2 pounds per acre of borax was not harmful. The evidence indicates that 5 pounds is the largest amount of borax per acre that can be used on corn and that, even at this rate, injury may occur when the material is applied in drills below the seed.

The 10 and 20-pound treatments were toxic, under the conditions of the tests, and caused most of the seedlings either to fail to appear or to turn white and die. The few which grew were stunted and exhibited banded bleaching.

Lime and gypsum as well as manure appeared to neutralize some of the toxic effect of borax.

The results obtained from using a ready-mixed commercial fertilizer containing borax were much the same as those resulting from the use of borax-fertilizer mixtures made from tested chemicals.

EFFECTS ON BEANS

Borax applied at the rate of 2 pounds per acre caused no injury to the growth of beans while with a 4-pound application the characteristic injury and stunting of growth was quite marked. Under the conditions of the experiment, the toxic

limit for this plant was in the neighborhood of 3 pounds of borax per acre when applied in drills. When broadcasted the toxic limit was about 5 pounds per acre. Most of the plants in the 10-pound and all of those in the 20-pound-per-acre borax applications either died or failed to appear above the soil.

Young bean plants are especially sensitive towards borax injury. For that reason borax-fertilizer applications in drills, particularly in drills below the seed, are more toxic than broadcasted applications, since the young roots come into contact with dissolved borax earlier and since the borax solution is more concentrated at first, when applied in drills.

Given amounts of borax which were toxic towards germination and growth in soil held at a 30 per cent moisture content were much more toxic in soil containing half as much water.

In a comparison of borax-fertilizer mixtures with a commercial fertilizer, containing an equivalent amount of borax, the same type of injury occurred in both cases and the commercial fertilizer was more toxic. Since the leaves in the latter case contained a greater quantity of boron it is believed that the super-toxicity of the commercial fertilizer was not due to some additional deleterious substance, but rather to a slower dissolving and leaching away of the naturally incorporated borax which would cause the young roots to come into contact with borax for a greater length of time.

Hydrated lime neutralized a part of the toxic effect of borax, particularly when mixed and applied in drills with the borax-fertilizer mixtures. The applications of gypsum and manure did not retard the toxicity of borax to any appreciable extent.

METEOROLOGICAL OBSERVATIONS.

For many years the meteorological apparatus was located in the Experiment Station building and the observations were made by members of the Station Staff. June 1, 1911, the meteorological apparatus was removed to Wingate Hall and the observations are in charge of Dr. James S. Stevens, professor of physics in the University of Maine.

In September, 1914, the meteorological apparatus was moved to Aubert Hall, the present headquarters of the physics department.

The instruments used are at Lat. $44^{\circ} 54' 2''$ N. Lon. $64^{\circ} 40' 5''$ W. Elevation 135 feet.

The instruments used are the same as those used in preceding years, and include: Maximum and minimum thermometers; rain gauge; self-recording anemometer; vane; and barometers. The observations at Orono now form an almost unbroken record of fifty-three years.

METEOROLOGICAL SUMMARY FOR 1921.
Observations Made at the University of Maine.

METEOROLOGICAL OBSERVATIONS.

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REPORT OF THE TREASURER.

The Station is a department of the University and its accounts are kept in the office of the Treasurer of the University. The books, voucher files, etc., are, however, all distinct from those of the other departments of the University. The classification of accounts is that prescribed by the auditors on the part of the Federal Government, and approved by the State Auditor. All of the accounts are audited by the State Auditor, and the Hatch Fund and Adams Fund accounts are also audited by the Office of Experiment Stations acting for the United States Secretary of Agriculture in accordance with Federal Law.

The income of the Station from public sources for the year that ended June 30, 1921, was:

U. S. Government, Hatch Fund appropriation.....	\$15,000.00
U. S. Government, Adams Fund appropriation.....	15,000.00
State of Maine, Animal Husbandry investigation appropriation	5,000.00
State of Maine, Aroostook Farm investigation.....	5,000.00
State of Maine, Highmoor Farm investigations.....	5,000.00

The cost of maintaining the laboratories for the inspection analyses is borne by analysis fees and by the State Department of Agriculture. The income from sales at the experiment farms is used for the expense of investigations. The printing is paid for by an appropriation to the University.

At Aroostook Farm there are in connection with the cooperative work with the Federal Department of Agriculture expenditures mostly under "labor" for the Department and for which the Station is reimbursed. There are also certain expenditures for the Department made from sales of crops from Department investigations that do not appear in the tabular statements. They are carried as distinct and separate accounts, always with credit balances, on the Station ledger.

REPORT OF THE TREASURER FOR YEAR ENDING JUNE 30, 1921.
DISBURSEMENTS.

	Hatch Fund	Adams Fund	Animal Husbandry Investigations
Salaries	\$8887.12	\$11532.55	\$2050.02
Labor	1368.44	825.94	1612.58
Publications	159.93	-----	5.10
Postage and Stationery.....	390.89	73.23	129.38
Freight and Express.....	71.89	88.85	100.81
Heat, light and power.....	615.16	115.93	10.00
Chemical and laboratory supplies.....	8.00	119.70	-----
Seeds, plants and sundry supplies.....	246.89	154.91	194.13
Fertilizers	333.16	-----	-----
Feeding stuffs.....	2460.05	1161.35	1098.39
Library	190.26	14.60	-----
Tools, machinery and appliances.....	339.34	3.15	23.20
Furniture and fixtures.....	42.25	53.00	50.00
Scientific apparatus and specimens.....	29.01	220.28	-----
Live stock.....	-----	114.45	-----
Traveling expenses.....	315.93	427.61	52.23
Contingent expenses.....	25.62	20.00	223.00
Buildings	16.15	79.36	62.59
Total.....	\$15000.00	\$15000.00	\$5611.34

REPORT OF THE TREASURER FOR YEAR ENDING JUNE 30, 1921.
DISBURSEMENTS.

	Aroostook Farm	Highmoor Farm	General Account	Inspection Analysis
Salaries -----	\$1200.00	\$1350.02	\$ 562.02	\$11225.67
Labor -----	5694.86	3699.39	3525.91	-----
Publications -----	-----	-----	5.52	-----
Postage and Stationery-----	44.36	37.70	211.55	247.90
Freight and Express-----	22.16	30.74	390.11	108.08
Heat, light and power-----	110.74	402.31	1458.29	364.00
Chemical and laboratory supplies-----	-----	12.50	10.94	204.38
Seeds, plants and sundry supplies-----	626.17	640.96	632.33	84.04
Fertilizers -----	1292.13	731.91	80.00	-----
Feeding stuffs-----	922.16	159.98	3766.04	-----
Library -----	-----	-----	640.64	6.00
Tools, machinery and appliances-----	458.66	744.91	924.01	-----
Furniture and fixtures-----	3.22	192.32	121.24	29.22
Scientific apparatus and specimens-----	-----	-----	7.89	30.15
Live stock-----	277.00	-----	1229.62	-----
Traveling expenses-----	10.05	18.84	352.98	152.83
Contingent expenses-----	119.22	100.84	146.50	30.80
Buildings -----	157.35	731.02	610.89	3.58
Total-----	\$10938.08	\$8848.39	\$14676.48	\$12486.65

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THIRTY-SEVENTH ANNUAL REPORT

OF THE

Maine Agricultural Experiment Station

ORONO, MAINE

1921

UNIVERSITY OF MAINE

1921

MAINE
AGRICULTURAL EXPERIMENT STATION
ORONO, MAINE

ORGANIZATION JANUARY TO JUNE, 1921
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AND THE HEADS AND ASSOCIATES OF STATION DEPARTMENTS, AND THE
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AROOOSTOOK FARM	{ E. RAYMOND RING, A. B.,	Assistant Biologist Superintendent
HIGHMOOR FARM	{ WELLINGTON SINCLAIR, HUGH C. MCPHEE, B. S.,	Superintendent Scientific Aid

*To April 15

MAINE
AGRICULTURAL EXPERIMENT STATION
ORONO, MAINE

ORGANIZATION JULY TO DECEMBER, 1921

THE STATION COUNCIL

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LEONARD C. HOLSTON, Cornish,	<i>Maine Livestock Breeders' Ass'n.</i>
WILLIAM G. HUNTON, Portland,	<i>Maine Seed Improvement Ass'n.</i>

AND THE HEADS AND ASSOCIATES OF STATION DEPARTMENTS, AND THE
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HIGHMOOR FARM	WELLINGTON SINCLAIR,	<i>Superintendent</i>
	HUGH C. MCPHEE, B. S.,	<i>Scientific Aid†</i>

*From April 15.

†Resigned November 1.

The publications of this Station will be sent free to any address in Maine. All requests should be sent to

Agricultural Experiment Station,
Orono, Maine.

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ANNOUNCEMENTS.

ESTABLISHMENT OF THE STATION

The Maine Fertilizer Control and Agricultural Experiment Station, established by Act of the Legislature approved March 3, 1885, began its work in April of that year in quarters furnished by the College. After the Station had existed for two years, Congress passed what is known as the Hatch Act, establishing agricultural experiment stations in every state. This grant was accepted by the Maine Legislature by an Act approved March 16, 1887, which established the Maine Agricultural Experiment Station as a department of the University. The reorganization was effected in June, 1887, but work was not begun until February 16, 1888. In 1906, Congress passed the Adams Act for the further endowment of the stations established under the Hatch Act.

The purpose of the experiment stations is defined in the Act of Congress establishing them as follows:

"It shall be the object and duty of said experiment stations to conduct original researches or verify experiments on the physiology of plants and animals; the diseases to which they are severally subject, with the remedies for the same; the chemical composition of useful plants at their different stages of growth; the comparative advantage of rotative cropping as pursued under a varying series of crops; the capacity of new plants or trees for acclimation; the analysis of soils and water; the chemical composition of manure, natural and artificial, with experiments designed to test their comparative effects on crops of different kinds; the adaptation and value of grasses and forage plants; the composition and digestibility of the different kinds of food for domestic animals; the scientific and economic questions involved in the production of butter and cheese; and such other researches or experiments bearing directly on the agricultural industry of the United States as may in each case be deemed advisable, having due regard to the varying conditions and needs of the respective states or territories."

The work that the Experiment Station can undertake from the Adams Act fund is more restricted and can "be applied only to paying the necessary expenses for conducting original researches or experiments bearing directly on the agricultural industry of the United States, having due regard to the varying conditions and needs of the respective states and territories."

INVESTIGATIONS.

The Station continues to restrict its work to a few important lines, believing that it is better for the agriculture of the State to study thoroughly a few problems than to spread over the whole field of agricultural science. It has continued to improve its facilities and segregate its work in such a way as to make it an effective agency for research in agriculture. Prominent among the lines of investigation are studies upon the food of man and animals, the diseases of plants and animals, breeding of plants and animals, orchard and field experiments, poultry investigations, and entomological research.

INSPECTIONS.

Up to the close of the year 1913, it had been the duty of the Director of the Station to execute the laws regulating the sale of agricultural seeds, apples, commercial feeding stuffs, commercial fertilizers, drugs, foods, fungicides and insecticides, and the testing of the graduated glassware used by creameries. Beginning with January, 1914, the purely executive part of these laws is handled by the Commissioner of Agriculture. It is still the duty of the Director of the Station to make the analytical examination of the samples collected by the Commissioner and to publish the results of the analyses. The cost of the inspections is borne by fees and by a State appropriation.

OFFICES AND LABORATORIES.

The offices, laboratories and poultry plant of the Maine Agricultural Experiment Station are at the University of Maine, Orono. Orono is the freight, express, post, telegraph and telephone address for the offices and laboratories.

AROOSTOOK FARM.

By action of the Legislatures of 1913 and 1915 a farm was purchased in Aroostook County for scientific investigations in agriculture to be under "the general supervision, management, and control" of the Maine Agricultural Experiment Station. The farm is in the town of Presque Isle, about 2 miles south of the village, on the main road to Houlton. The Bangor and Aroostook railroad crosses the farm. A flag station, "Aroostook Farm," makes it easily accessible by rail.

The farm contains about 275 acres, about half of which is cleared. The eight room house provides an office, and home for the farm superintendent. A school house on a lot adjoining the farm was presented to the State by the town of Presque Isle and after being remodeled serves as a boarding house for the help. A greenhouse and a potato storage house have been erected at the farm by the U. S. Department of Agriculture for use in cooperative work on potato breeding. The large barn affords storage for hay and grain and has a large potato storage house in the basement.

HIGHMOOR FARM.

The State Legislature of 1909 purchased a farm upon which the Maine Agricultural Experiment Station was directed to "conduct scientific investigations in orcharding, corn and other farm crops." The farm is situated largely in the town of Monmouth. It is on the Farmington Branch of the Maine Central Railroad, 2 miles from Leeds Junction. A flag station, "Highmoor," is on the farm.

The farm contains 225 acres, about 200 of which are in orchards, fields, and pastures. There are in the neighborhood of 3,000 apple trees upon the place which have been set from 20 to 30 years. The house has 2 stories with a large wing, and contains about 15 rooms. It is well arranged for the Station offices and for the home of the farm superintendent. A substantially constructed building for apple packing was erected in 1912.

The removal of the crossbred herd from the University to Highmoor necessitated considerable change in the barns and the building of a new one 80 x 36 to accommodate the herd. This barn has a basement for manure, the cow stanchions above, and

a loft for storage of hay. The silo has been enlarged and a long shed has been made into calf pens. A well to supply the necessary water has been driven.

PUBLICATIONS.

The Station is organized so that the work of investigation is distinct from the work of inspection. The results of investigation are published in the bulletins of the Station and in scientific journals, both foreign and domestic. The bulletins for the year make up the annual report. The results of the work of inspection are printed in publications known as Official Inspections. These are paged independently of the bulletins and are bound in with the annual report as an appendix thereto. Miscellaneous publications consisting of newspaper notices of bulletins, newspaper bulletins and circulars which are not paged consecutively and for the most part are not included in the annual report are issued during the year.

BULLETINS ISSUED IN 1921.

- No. 296. Orthoptera of Maine. 36 pages.
- No. 297. Potato Leafroll. 16 pages. 4 pages of plates.
- No. 298. Studies in Orchard Management. 32 pages.
- No. 299. Report of Progress on Animal Husbandry Investigations in 1920.
36 pages.
- No. 300. Studies in Milk Secretion. IX. On the Performance of the Progeny of Holstein-Friesian Sires. 132 pages.
- No. 301. Studies in Milk Secretion. XII. Transmitting Qualities of Holstein-Friesian Sires for Milk Yield, Butter-Fat Percentage and Butter-Fat. 56 pages.
- No. 302. A Meadow Caterpillar. 12 pages. 2 pages of plates.
- No. 303. Rose Bushes in Relation to Potato Culture. 24 pages.

OFFICIAL INSPECTIONS ISSUED IN 1921.

- No. 99. Foods and Drugs. 20 pages.
- No. 100. Commercial Feeding Stuffs, 1920-21. 40 pages.
- No. 101. Commercial Fertilizers, 1921. 20 pages.
- No. 102. Commercial Agricultural Seeds, 1921. Insecticides and Fungicides, 1920 and 1921. 20 pages.

MISCELLANEOUS PUBLICATIONS ISSUED IN 1921.

- No. 540. List of Available Publications. 2 pages.
- No. 541. Grasshoppers and Related Insects. 6 pages.

BIOLOGICAL PUBLICATIONS, 1921.

- In the numbered series of "Papers from the Biological Laboratory":
- 137. Sterility in wheat hybrids. I. Sterility relationships and endosperm development. By Karl Sax. *Genetics*, Vol. 6, pp. 399-416, July, 1921.
 - 138. Studies in orchard management. II. Factors influencing fruit developments in the apple. By Karl Sax. *Annual Report of the Maine Agricultural Experiment Station for 1921*. Bulletin 298, pp. 53-84.
 - 139. Report of progress on animal husbandry investigations in 1920. By John W. Gowen. *Annual Report of the Maine Agricultural Experiment Station for 1921*. Bulletin 299, pp. 85-120.
 - 140. Studies on conformation in relation to milk producing capacity in cattle. II. The personal equation of the cattle judge. By John W. Gowen. *Journal of Dairy Science*, Vol. IV, No. 5, pp. 359-374, September, 1921.
 - 141. Identical twins in cattle. By John W. Gowen. *Biological Bulletin*, Vol. XLII, No. 1, pp. 1-7, January, 1922.
 - 142. Complete linkage in *Drosophila melanogaster*. By Marie S. Gowen and John W. Gowen. *American Naturalist*.
 - 143. Studies in milk secretion. IX. On the performance of the progeny of Holstein Friesian sires. By John W. Gowen and Mildred R. Covell. *Annual Report of the Maine Agricultural Experiment Station for 1921*. Bulletin 300, pp. 121-252.
 - 144. Studies in milk secretion. X. The relation between the milk yield of one lactation and the milk yield of a subsequent lactation in Guernsey Advanced Registry cattle. By John W. Gowen. *Journal of Dairy Science*.
 - 145. Studies in milk secretion. XI. The relation between the butter-fat percentage of one lactation and the butter-fat percentage of a subsequent lactation in Guernsey Advanced Registry cattle. By John W. Gowen. *Journal of Dairy Science*.
 - 146. Studies in orchard management. III. Bud variation and tree performance in clonal varieties. By Karl Sax and John W. Gowen.
 - 147. Wheat investigations. II. Correlations between various characters of wheat and flour as determined from published data from chemical, milking and baking test of a number of American wheats. By Jacob Zinn. *Journal of Agricultural Research*.
 - 148. Studies in milk secretion. XII. Transmitting qualities of Holstein-Friesian sires for milk yield, butter-fat percentage and butter-fat. By John W. Gowen and Mildred R. Covell. *Annual Report of the Maine Agricultural Experiment Station for 1921*. Bulletin 301, pp. 253-308.
 - 149. Studies in milk secretion. XIII. Relation between the milk yields and butter-fat percentages of the 7 day and 365 day tests of Holstein-Friesian Advanced Registry cattle. By John W. Gowen. *Journal of Dairy Science*.
 - 150. Studies in orchard management. IV. Productive and unproductive types of apple trees. By Karl Sax and John W. Gowen. *Journal of Heredity*, Vol. XII, No. 7, pp. 290-350.

MISCELLANEOUS PUBLICATIONS FROM THE BIOLOGICAL LABORATORY IN 1921.

Chromosome relationships in wheat. By Karl Sax. *Science N. S.*, Vol. LIX, No. 1400, pp. 413-415. October 28, 1921.

Simple device for weighing seeds. By Karl Sax. *The Botanical Gazette*, Vol. LXXI, No. 5, p. 399. May, 1921.

MISCELLANEOUS PUBLICATIONS FROM THE PLANT PATHOLOGICAL LABORATORY IN 1921.

Leafroll, Net-Necrosis and Spindling Sprout of the Irish Potato. By Donald Folsom (joint-author). *Journal of Agricultural Research*, Vol. XXI, No. 1, pp. 47-80.

Effects Upon the Growth of Potatoes, Corn and Beans Resulting from the Addition of Borax to the Fertilizer Used. By W. J. Morse (joint-author). *Soil Science*, Vol. 12, pp. 79-105, August, 1921.

STATION NOTES

COUNCIL AND STAFF CHANGES

At the June meeting of the Board of Trustees of the University of Maine, Hon. Frank E. Guernsey of Dover was reappointed a member of the Council. This was to fill the place made vacant by the death of Mr. Charles E. Oak, which occurred April 17, 1921. At the annual meeting of the State Dairymen's Association Mr. John W. Leland of Dover was selected as their representative to fill the vacancy caused by the death of Mr. Frank S. Adams which occurred during the previous year.

The Station during the War and the period of high prices immediately following has been obliged to carry on its work with the same income that it had for several years previously. It became necessary to curtail expenditures in every possible manner. One way to meet the situation was to refrain from filling vacancies where resignations occurred. While the disastrous results sure to follow such a policy with reference to the quality and quantity of the Station work are appreciated, it has been necessary to adopt it in considerable extent. Hence no new appointments were made to fill vacancies which had previously occurred and the Station staff is smaller than it has been for some years. Mr. Hugh C. McPhee resigned as Scientific Aid on November 1. Warner J. Morse was appointed Director on April 15, retaining at the same time the duties of Plant Pathologist.

